

Small Aircraft Transportation System, Higher Volume Operations Concept: Normal Operations

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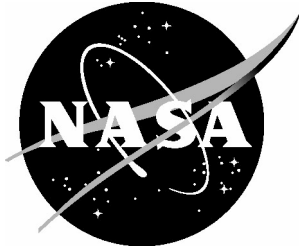
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Nomenclature

ADS-B:	Automatic Dependent Surveillance - Broadcast
AGL:	Above Ground Level
AMM:	Airport Management Module
ATC:	Air Traffic Control
CD&A:	Conflict Detection and Alerting
CD&R:	Conflict Detection and Resolution
CPDLC:	Controller / Pilot Data Link Communication
ETD:	Expected Time of Departure
FN:	Follow Notification
GPS:	Global Positioning System
HVO:	Higher Volume Operations
IAF:	Initial Approach Fix
IFR:	Instrument Flight Rules
IMC:	Instrument Meteorological Conditions
LEN:	Lateral Entry Notification
MAHF:	Missed Approach Holding Fix
NAS:	National Airspace System
RCO:	Remote Communications Outlet
RNAV:	Area Navigation
SATS:	Small Aircraft Transportation System
SCA:	Self-Controlled Area
VEN:	Vertical Entry Notification
VFR:	Visual Flight Rules

Abstract

This document defines the Small Aircraft Transportation System, (SATS) Higher Volume Operations concept for normal conditions. The general philosophy underlying this concept is the establishment of a newly defined area of flight operations called a Self-Controlled Area (SCA). During periods of poor weather, a block of airspace would be established around these designated non-towered, non-radar airports. Aircraft flying enroute to a SATS airport would be on a standard instrument flight rules flight clearance with Air Traffic Control providing separation services. Within the SCA, pilots would take responsibility for separation assurance between their aircraft and other similarly equipped aircraft. Using onboard equipment and procedures, they would then approach and land at the airport. Departures would be handled in a similar fashion. The details for this operational concept are provided in this document.

Introduction

The intent of this document is to further expand and define the Small Aircraft Transportation System (SATS), Higher Volume Operations (HVO) operational concept (refs. 1-2). The general philosophy underlying this operational concept is the establishment of a newly defined area of flight operations called a Self-Controlled Area (SCA). During periods of instrument meteorological conditions (IMC), a block of airspace would be established around SATS designated non-towered, non-radar airports. Aircraft flying enroute to a SATS airport would be on a standard instrument flight rules (IFR) clearance with air traffic control (ATC) providing separation services. Within the SCA, pilots would take responsibility for separation assurance between their aircraft and other similarly equipped aircraft. Using onboard equipment and procedures, they would then approach and land at the airport. Departures would be handled in a similar fashion. Details of the transition procedures for entering and departing the SCA were also considered. The detailed design requirements and overall goals that were used as the basis for this operational concept are provided in reference 2.

While pilots would be required to take responsibility for self-separation within the SCA, they would not be required or allowed to take responsibility for sequencing their arrivals within the SCA. This concept would take advantage of a proposed ground-based automation system, called an Airport Management Module (AMM) that would provide sequencing information to pilots for safe and improved operations. The AMM would typically be located at the airport and would make these assignments based on calculations involving aircraft performance, aircraft position information, winds in the terminal area, missed approach requirements, and a set of predetermined operating rules for the SCA.

Because the SATS project is focused on achieving a realistic, operationally deployable system for the 2010 timeframe, this concept emphasized integration with the current and the planned near-term National Airspace System. As a result, the design approach focused on simplicity from both a procedural and systems requirements standpoint. It was further assumed that any additional ATC workload must be minimized and that enroute procedures would be as similar to today's system as possible. This concept is based on a distributed decision-making environment that would provide pilots the necessary procedures, airborne systems, traffic awareness, and aircraft sequence information to enable safe operations within the SCA while minimizing the requirements for the ground support tools. Because this is a distributed decision-making environment, much of the decision-making would be left with the pilot, as it is today

with visual flight rules (VFR) operations into these non-towered airports. Finally, the overall philosophy was to emphasize simplicity and operational safety as major aspects in the design.

Design of the Self-Controlled Area (SCA)

A plan view graphic depicting a generic SCA is shown in figure 1. It should be noted that the structure and configuration of the SCA might need to be uniquely defined for a specific airport environment. The airspace should meet current FAA airspace design criteria and comply with required standards for terrain avoidance, obstacle clearance, local traffic densities, and noise abatement procedures. The SCA would be similar in concept to a class E surface area and is similar to the proposal by Conway and Consiglio in reference 3. The waypoints could be existing waypoints for a generic RNAV GPS-T approach. In this concept, the outboard Initial Approach Fixes (IAFs) on the T (e.g., ANNIE and CATHY) would be used for all arrivals. These fixes would also be used as the missed approach holding fixes (MAHF). The outrigger IAFs on the opposite T (ELLEN and GINNY) could be used as the departure fixes. Due to the nominal location of these waypoints, and the requirement to protect the airspace around the holding patterns at these waypoints, the SCA would have a radius of approximately 10 nm. This would be a generic size and shape, established without any attempts to optimize the SCA size.

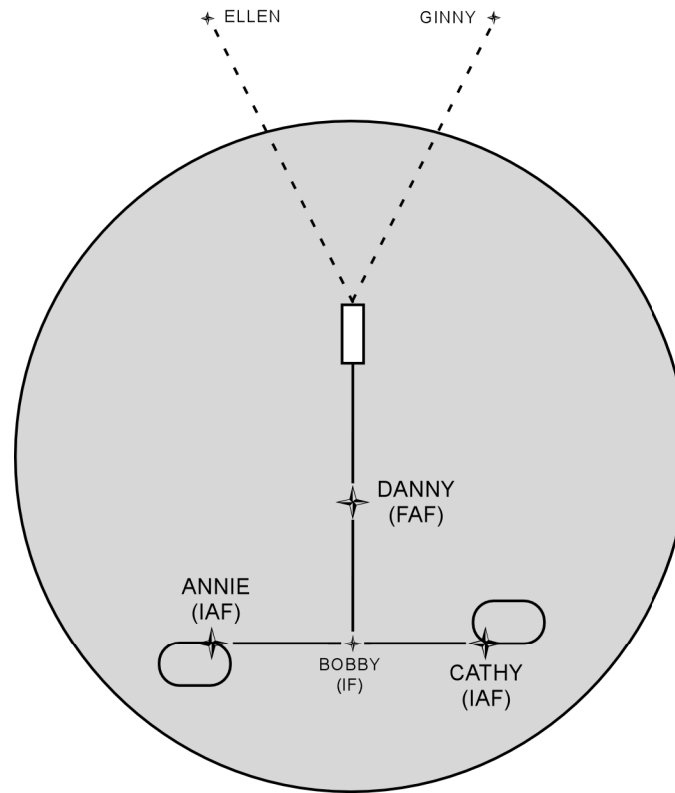


Figure 1. Plan view of the Self-Controlled Area

The concept of operations employed within the SCA was based roughly on the FAA's timed approach procedures, which can be utilized at airfields that have control towers. In this FAA procedure, the holding patterns and procedures are often compared to a stack of records. In the SCA operation, arriving aircraft would enter at the top of the stack, drop down in 1,000-foot increments as the altitude below becomes clear, until they reach the bottom of the stack. At that time, the aircraft would self-separate along the

approach path for landing. The purpose of the holding pattern in the SCA would be to delay aircraft while they are waiting for appropriate aircraft-to-aircraft separation prior to initiating the approach and landing.

The SATS HVO concept would not depend on a control tower or designated approach times but rather would allow the pilot, using onboard equipment, to descend and then follow the preceding aircraft as designated by the AMM. The pilot would use the onboard equipment to verify that the altitude and location to which his aircraft was descending was free of other traffic. Pilots would then continue down the stack until they arrive at the initial approach altitude (2000 feet AGL) at an IAF (e.g., CATHY). Once additional requirements were met, the pilot would depart the IAF and continue down the approach. To contain this concept, the height of the SCA was set nominally at 3000 feet above the airport with the holding locations placed in the SCA at the outboard IAFs (e.g., ANNIE and CATHY) at 2000 and 3000 feet at both locations. The profile view in figure 2 shows one of these holding locations and helps visualize the stack above the IAF. Note also that the shape of the SCA is similar to a Class C airspace design, but with an offset on the approach-side and the secondary tier (the higher tier) clipped on the departure-side. Under certain conditions, VFR flight may be allowed at altitudes below 700 feet above ground level. The SCA was sized so as to not penalize these VFR operations except in the immediate vicinity of the airport. Again, the altitudes proposed for this airspace are nominal. Other altitudes and configurations could be established based on proper analysis and design constraints.

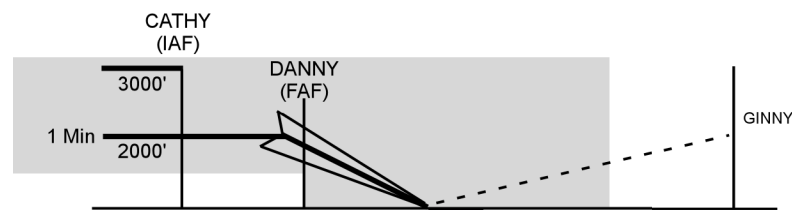


Figure 2. Profile view of the Self-Controlled Area

This concept further assumed that pilots would have the ability to contact ATC prior to entering and leaving the SCA. While communication was not required, it was assumed that airspace outside of the SCA would be under radar or other surveillance coverage by ATC. Although procedural separation could be used for aircraft entering and arriving into the SCA, if radar coverage was available adjacent to the SCA, transitions could be handled more efficiently. Outside of the SCA the airspace would be “owned” by ATC and ATC would be responsible for providing traditional separation services.

As noted previously, the AMM would consist of a ground-based automation system, typically located at the airport. It would be responsible for determining aircraft sequencing for departures. The AMM would not be an automation of the tower controller function but would be more of a simple counter that issues sequence information based on a set of predetermined rules. The AMM would rely on aircraft position information provided through a ground-based ADS-B receiver to manage the operations within the SCA. Aircraft would be expected to contact the AMM via data link and request landing sequence information. The AMM would then provide either a notification of which airplane the pilot would follow (if there were one in the sequence ahead of the pilot) or inform the pilot that he cannot initiate the operation (e.g., enter the SCA) along with a notification of the delay to expect before the operation could begin.

In addition to its other calculations, the AMM must also assure that there would be available missed approach airspace for each aircraft that was arriving in the SCA. Since it must be assumed that every approach may result in a missed approach and since there would not be an active controller involved in SCA operations (who could respond in real time with unique missed approach instructions), each aircraft

entering the SCA would be given specific missed approach information by the AMM as it enters the airspace. This technique would keep the ground-based automation relatively simple and less critical to the operational concept. However, it would mean that the total number of operations would be constrained by the number of unique missed approach locations that could exist within the SCA. For the SCA shown in figures 1 and 2, there are four missed approach holding options (2 holding altitudes at each missed approach holding fix), therefore there are a total of 4 approach operations allowed at one time in this version of a SCA. Again, it is expected that this design would be modified for specific airport and airspace configurations. Also note, however, that designs with significantly more missed approach fixes may not significantly increase the number of allowable landing operations.

Airports would only need to make relatively minimal infrastructure investments to increase their ability to sustain operations during periods of IMC. Airports would be expected to have weather reporting capability (e.g., AWOS) and would need to install an AMM, a ground based ADS-B receiver, and have a data link capability.

For this operational concept to be viable, a link between the AMM and ATC would be required. This link would be necessary to enable ATC to terminate and subsequently re-enable HVO operations when necessary to accommodate non-HVO operations. This link would also be necessary to efficiently enable HVO departure operations that would transition into traditional IFR airspace. Additionally, if controllers had access to the SCA status information, this could facilitate air traffic management. For example, if controllers knew that the SCA was not currently accepting aircraft (because the SCA was full), and that there would be a 20-minute delay at the airport; they could begin planning for that delay in advance.

As noted previously, the objective of this operational concept is to enable simultaneous operations by multiple aircraft in non-radar airspace at and around small non-towered airports in near all-weather conditions. The primary process used in the development of this document was a functional-flow technique. For each element of the operational concept, a sample scenario is provided to describe that aspect of the operation. Note that traditional operating rules and procedures may not be explicitly portrayed in the scenarios but are expected to apply.

Because a program objective focus was on a realistic, operationally deployable system for the 2010 timeframe, the design focus emphasized integration with current and planned near-term NAS operations and systems. In addition, the design approach focused on simplicity from both a procedural and systems requirements standpoint.

Conflict Detection and Alerting

An explicit design decision was made in the development of this concept in that neither conflict detection and alerting (CD&A) nor conflict detection and resolution (CD&R) would be required as a primary means for aircraft separation in conducting HVO. That is, the HVO procedures, with the supporting AMM design and relatively simple flight displays, would provide the primary means for aircraft-to-aircraft separation within the SATS SCA. It was assumed, however, that either conflict detection and alerting (CD&A) or conflict detection and resolution (CD&R) would be required as a secondary means for operational safety.

SCA Operating Rules

During the evolution of this concept, it became obvious to the developers that several operational principles and constraints fundamentally shaped the concept design, with the most significant being the requirements for missed approach airspace.

As previously noted, the total number of operations would be constrained by the number of unique missed approach locations that can exist within the SCA. For the generic SCA shown in figures 1 and 2, there are four missed approach positions, two at ANNIE and two at CATHY. Therefore, there would be a total of four approach operations allowed at one time in the generic SCA. From this maximum of four operations, exclusive of departure operations, a set of implementation and operating rules were developed. How these rules would be used in the context of the SATS operations are explained in the subsequent sections. The rules used in the development of the current design are as follows:

- No more than four concurrent arrival operations are allowed in the SCA.
- Simultaneous entries are not allowed at a single initial approach fix (IAF).
- Entries may not result in the assignment of more than 2 aircraft to a specific fix, with the assignment as either an initial approach fix or as a missed approach holding fix (MAHF).
- Vertical entries (described in a subsequent section) are only allowed at the IAFs from the lowest IFR altitude above the SCA.
- Upon entering the SCA at an IAF, aircraft are to go to the lowest available altitude and then continue to descend as altitudes below them become available.
- Alternating missed approach holding fixes are given to sequential aircraft (e.g., the first aircraft is given ANNIE, the second aircraft is given CATHY, the third aircraft is given ANNIE, etc.). Note that for operational efficiency reasons, if there were no other landing aircraft in the SCA, the first arriving aircraft would be assigned a "same-side" missed approach holding fix (e.g., if the arrival fix is ANNIE, the missed approach holding fix will be ANNIE).
- When proceeding to a holding fix on a missed approach, aircraft are to climb to the lowest available altitude (e.g., the first aircraft heading to ANNIE climbs to 2000 feet, the next aircraft going to ANNIE climbs to 3000 feet).
- Aircraft operating in the SCA must be able to climb at 300 feet per mile (required for maintaining separation when climbing to the highest altitude of a missed approach fix if the lower altitude is occupied).

Normal Procedures

Preliminary Data Exchange while in Enroute ATC Airspace

No unique SATS provisions were anticipated for filing and following flight plans, so the pilot would simply be required to file a traditional IFR flight plan to the SATS destination airport. The aircraft special equipment designator on the flight plan would identify the aircraft to ATC as SATS capable. The final fix

in the route-of-flight section of the flight plan would be a SATS transition fix, which would be an IAF for a SATS instrument approach at the destination SATS airport.

Note that the AMM would be broadcasting the total number of aircraft that are either sequenced for landing within the SCA or are requesting entry from outside the SCA. This information could be used by the pilot in considering alternate airport options.

Prior to reaching the transition fix, the pilot would request a landing assignment from the AMM (fig. 3). Note that the SATS aircraft would be broadcasting, via data link, the planned IAF. (Also note that while the SCA is depicted as a single cylinder in figure 3, it is actually a two-tiered volume, as depicted in figure 2.) To be eligible to request a landing sequence, the SATS aircraft must be within 5 minutes of a 5 nm radius around the planned IAF, with the time based on the aircraft's closure rate with that fix. The AMM would then determine a sequence number for the arriving aircraft relative to other aircraft already in the SCA. If an arrival opening were available, the AMM would issue an entry notification. If the SCA were "full," the AMM would issue a "STANDBY" notification. The scenario sequence for this operation is shown in table 1. This table portrays the chronological order in which airplane or pilot actions, ATC actions, and AMM action occur for a typical scenario defining this phase of the SATS operation.

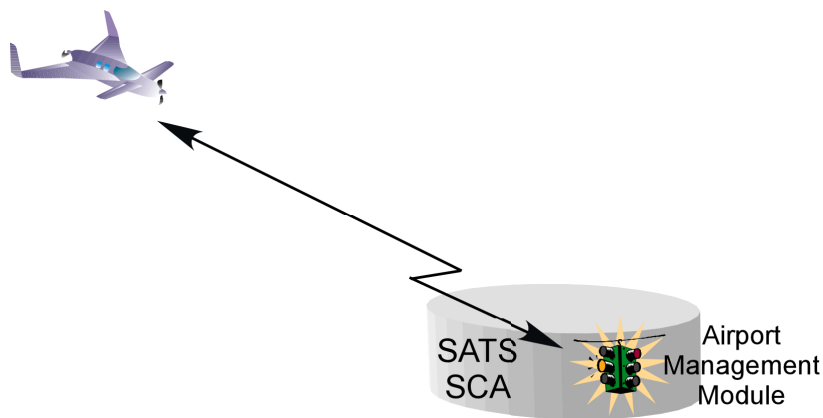


Figure 3. Preliminary data exchange.

Table 1. Preliminary Data Exchange.

Sequence of Events		
SATS Aircraft / Pilot	ATC	AMM
On a standard IFR flight plan to the SATS airport. The current clearance is to "ANNIE" at 4000 ft.		Broadcasts number of approach-requesting aircraft.
Obtains the ATIS information for the airport.		
Requests an approach sequence from the AMM. Aircraft broadcasts planned IAF.		A sequence number is computed.

Vertical Transition from Enroute ATC Airspace into the SATS SCA

As previously noted, ATC would clear the SATS aircraft to the SATS transition fix, which would be an IAF at the SATS airport. This clearance to the fix would be at an altitude above the SCA (fig. 4). Prior to reaching the transition fix, the aircraft would communicate with the AMM. Without an arrival opening in the SCA, the SATS aircraft would need to hold at an altitude above the SCA. Once the airspace was available and this SATS aircraft was at the lowest IFR altitude above the SCA, the AMM would issue a vertical entry notification (VEN) and a follow notification (FN) to the SATS aircraft. The FN pairs the SATS aircraft with the aircraft it would follow. If there were no preceding aircraft to follow, the pairing would indicate “none.” The SATS pilot would then request a descent from ATC.

If an approach sequence were not currently available, the AMM would continue to issue a STANDBY message. The AMM would also continue to broadcast the number of SCA arrival operations. This information may then be used by the pilot to estimate the landing delay. The SATS pilot may then notify ATC when he would expect to request a descent into the SCA. The scenario sequence for this operation is shown in table 2.

All of the following rules must be met prior to the AMM permitting a normal entry into the SCA:

- There are less than 2 aircraft either at the initial approach fix or assigned to the fix (i.e., as a missed approach holding fix).
- There are no other entries in progress at the specific fix.
- No other aircraft that are assigned to that fix as a missed approach holding fix are on the approach.
- The entry will not result in the assignment of more than 2 aircraft to the fix as either an initial approach fix or as a missed approach holding fix.

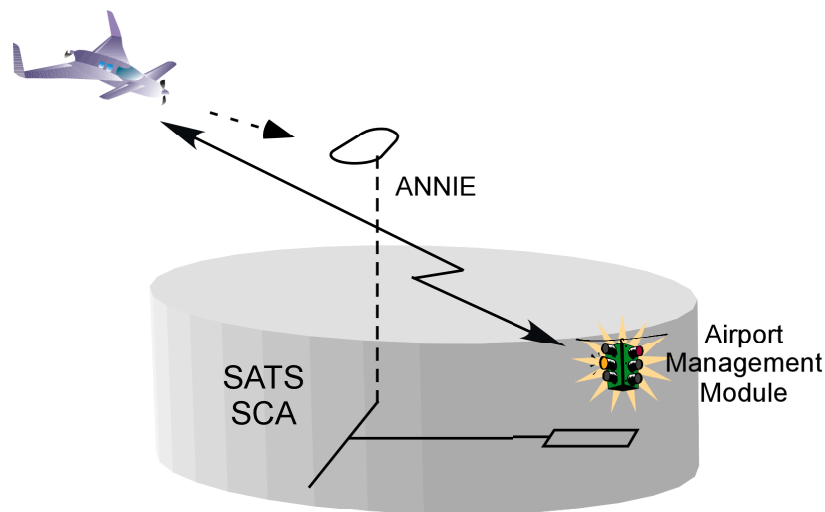


Figure 4. ATC clearance to the transition fix.

Table 2. Vertical Transition from Enroute ATC Airspace.

Sequence of Events		
SATS Aircraft / Pilot	ATC	AMM
Contacts ATC and advises of a 20 minute delay (estimated by the pilot based on the number of preceding aircraft) ¹ .	ATC issues a holding instruction to the SATS pilot: " <i>N1234S, hold at ANNIE, 4000 feet. Advise when ready to enter the SCA.</i> " Note that ANNIE has a depicted, enroute holding pattern ¹ .	Broadcasts that there are 6 preceding traffic ¹ . Once SCA airspace is available, issues a VEN, a FN, and missed approach information.

¹ Only required for a delay

Vertical Entry into SATS HVO Airspace

Once the airspace below the SCA transition altitude becomes available and the SATS aircraft is at the lowest IFR altitude above the SCA, the AMM would issue a vertical entry notification (VEN) and a follow notification (FN) to the SATS aircraft. This airspace availability would occur as the preceding aircraft (at the same IAF) also descends or begins the approach (fig. 5). As noted previously, the FN would identify the aircraft that the SATS pilot would eventually be following on the approach. If there was no leading aircraft, the FN would contain a "none" message. The AMM would also provide missed approach information based on this aircraft's sequence (see the *Missed Approach* section). The SATS pilot would then confirm, via the SATS display, that he was cleared to descend into the SCA. The SATS pilot then requests a clearance to descend from ATC. Once cleared by ATC, the SATS pilot would descend at the IAF to the lowest available altitude at that fix per the SATS procedure. The scenario sequence for this operation is shown in table 3.

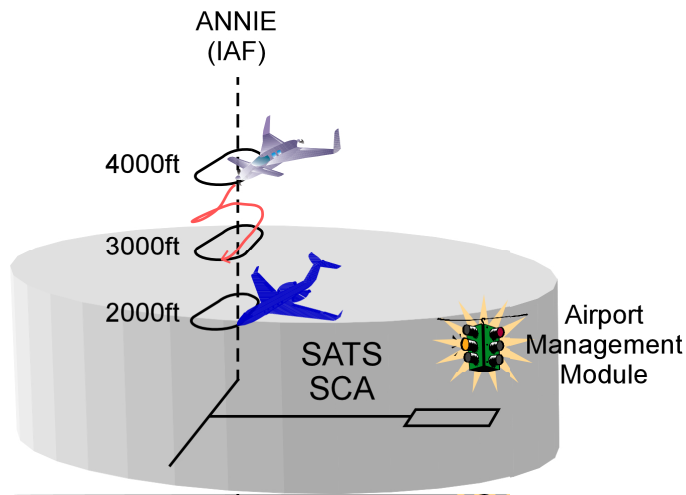


Figure 5. Vertical entry into the SCA at the transition fix.

Table 3. Vertical Entry into SATS HVO Airspace.

Sequence of Events		
SATS Aircraft / Pilot	ATC	AMM
<p>Confirms open slot at 3000ft and above or behind the aircraft identified in the FN.</p> <p>Requests descent.</p> <p>Descends into SCA, holding at transition fix at 3000ft¹.</p> <p>Descends to the lowest possible altitude at the transition fix / IAF.</p>	<p>Clears aircraft for descent.</p>	<p>Determines that at least one slot is available, that one slot is open at the transition fix, that the SATS aircraft is at the lowest IFR altitude above the SCA. Issues IAF, VEN, FN, and missed approach information.</p>

¹ only required if there is an aircraft at lower altitude at the transition fix / IAF.

Lateral Transition and Entry into SATS HVO Airspace

The intent of the lateral entry would be to allow, during periods of low-demand, a SATS aircraft to directly transition into the SCA at an altitude below the ceiling of the SCA. Because the SCA demand level may not be known until the aircraft reaches the vicinity of the SCA, a lateral entry into the SCA should not be flight-planned or expected by the SATS pilot.

As noted previously, once a SATS aircraft gets within five minutes of a 5 nm radius around the planned IAF, that SATS aircraft would become eligible to request a landing sequence. To accommodate a lateral entry capability, the SCA was divided into three areas: one departure area (in figure 6, this is the top area of the SCA, shown in white) and two arrival areas (in figure 6, the yellow and blue areas). To determine if a lateral entry would be permissible, the AMM would use the following special rules:

- If any other aircraft was at the IAF or was assigned to the IAF (e.g., for a missed approach), a Lateral Entry Notification (LEN) would not be allowed.
- If the arriving aircraft was on the departure-side of the SCA (in figure 6, this is the top area of the SCA, shown in white), a LEN would not be allowed.
- If the arriving aircraft would transition more than one arrival area, a LEN would not be allowed.
- If the entry would result in the assignment of more than 2 aircraft to a fix as either an initial approach fix or as a missed approach holding fix, a LEN would not be allowed.
- If there were no exceptions, the AMM would allow a LEN.

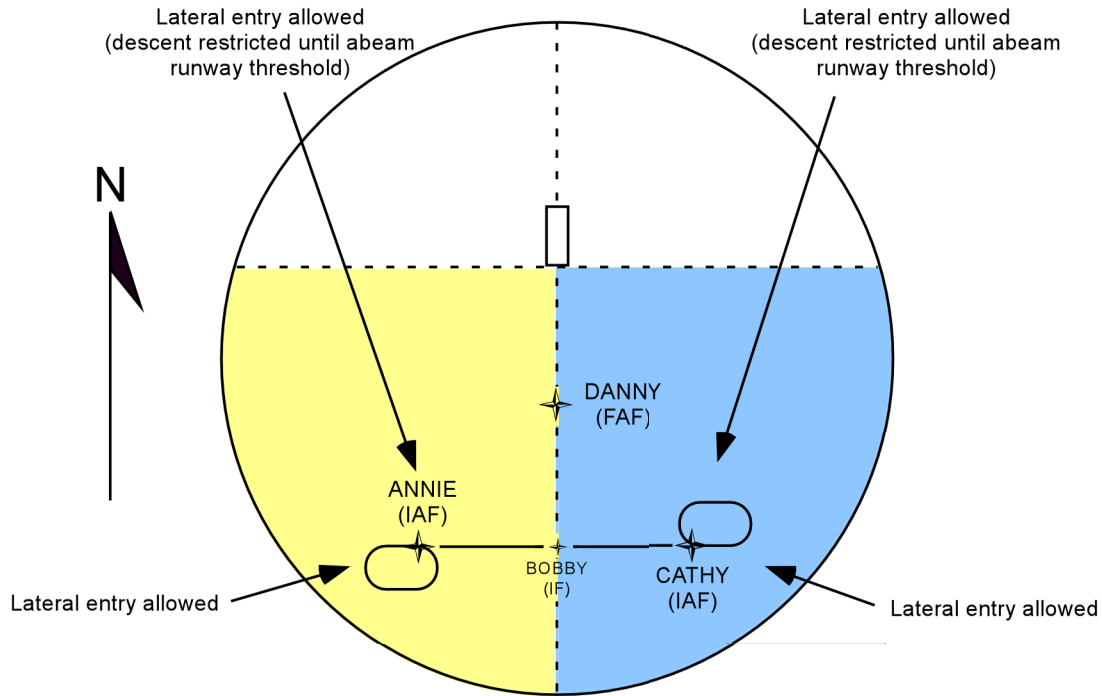


Figure 6. Lateral entry areas. Note that the yellow and blue areas extend outside of the circle in the respective quadrants.

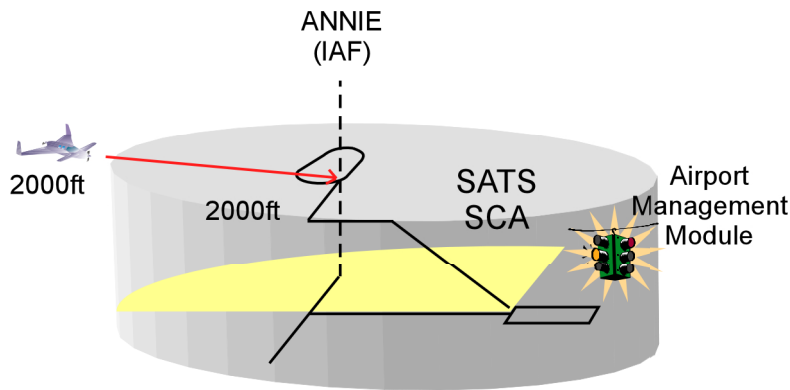


Figure 7. Lateral entry into the SCA.

If the arriving SATS aircraft were provided a lateral-entry notification (LEN), a normal follow notification (FN) and missed-approach instructions would also be issued from the AMM. If a lateral entry was not possible (before the aircraft reached the vicinity of the IAF), the AMM would issue a STANDBY message and the SATS pilot should expect a normal (vertical) SCA entry. If a LEN were not currently possible, the entry rules would be re-applied by the AMM. Once a LEN is issued, the SATS pilot would then request a clearance from ATC to depart ATC controlled airspace (fig. 7). Note that a descent to the IAF approach altitude may also begin at this time assuming that all other constraints were met (e.g., approval from ATC while in ATC airspace and maintaining at or above obstruction clearance altitudes). Once at the IAF, the SATS pilot would descend at the IAF to the lowest available altitude at that fix per the SATS procedure. The scenario sequence for this operation is shown in table 4.

Table 4. Lateral Transition from Enroute ATC Airspace.

Sequence of Events		
SATS Aircraft / Pilot	ATC	AMM
<p>On a standard IFR flight plan to the SATS transition fix, "ANNIE," at 2000 ft.</p> <p>Aircraft sends planned IAF and landing request.</p> <p>Confirms that there are no other aircraft at ANNIE.</p> <p>Requests clearance to depart ATC controlled airspace, transition prior to ANNIE at 2000ft.</p> <p>Transitions into the SCA at 2000ft and continues direct routing to ANNIE.</p>	<p>Clears aircraft to leave ATC airspace.</p>	<p>Determines that a lateral entry is permissible at ANNIE.</p> <p>Prior to ANNIE, provides LEN, FN, and missed approach information.</p>

Continued Descent at the Initial Approach Fix

As the airspace becomes available at lower levels at the IAF, the SATS pilot would descend to that level. This availability would occur as the preceding aircraft also descends or begins the approach (fig. 8). The scenario sequence for this operation is shown in table 5.

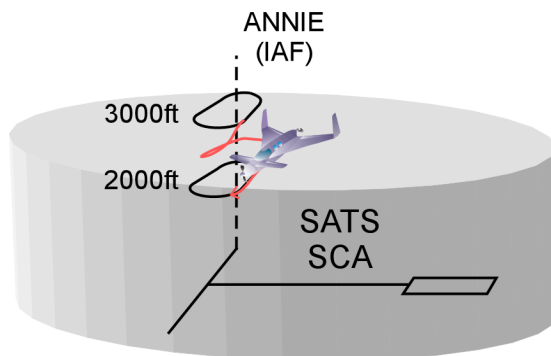


Figure 8. Descending at the initial approach fix.

Table 5. Continued Descent at the Initial Approach Fix.

SATS Aircraft / Pilot	Sequence of Events	
	ATC	AMM
Determines that a lower level is available at the transition fix.		
Descends to 2000ft.		

Initiating the Approach

As noted previously, the AMM would be responsible for determining the aircraft sequence for the approach. In addition, the AMM sequence process would also assure that there would be available missed approach airspace for this aircraft prior to issuing a FN.

Given the FN, the SATS pilot must determine if the preceding aircraft would be sufficiently ahead, based on a self-spacing interval, such that he could begin his own approach. Note that the leading aircraft could be at the opposite IAF (e.g., CATHY).

All SATS aircraft should be able to self-space using a baseline procedure. This baseline procedure would be used to delay at the IAF until the spacing from the lead aircraft met the spacing criteria. SATS pilots desiring greater efficiency could be helped through onboard tools that would enable the pilot to dynamically manage spacing. In this latter case, this determination would be based on his aircraft's own planned performance, the actual and planned performance for the preceding aircraft, the approach geometry, wind conditions, and other factors. Once the spacing criterion had been met, the pilot would leave the holding pattern and initiate the approach (fig. 9). The scenario sequence for this operation is shown in table 6.

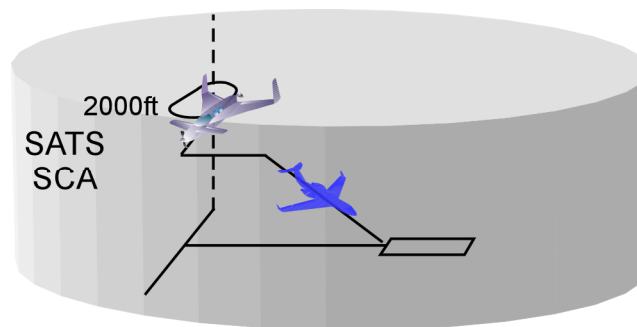


Figure 9. Initiating the approach.

Three proposals have been developed for approach initiation and approach spacing. The order of these proposals is from low efficiency and low complexity to high efficiency and high complexity. Note that low efficiency relates to a high "error budget" in the design. That is, if only low fidelity data or little processing was required, a large error allowance would be required for operational acceptability. Also note that these procedures would probably be unique or customized for each approach. The three proposals are:

- Simple charted procedure: For example, when the leading aircraft was 6 miles from the runway (as would be shown on the SATS approach display), the SATS pilot could start his approach.

- Pair-wise initiation: A somewhat more efficient but more complex alternative to this concept would be an approach speed based technique, where the pair-wise differences in the planned approach speeds (both before and after the final approach fix for both aircraft) would be used in the determination of the aircraft separation prior of the initiation of the approach.
- Active spacing: The most sophisticated and efficient technique would begin with the previously described pair-wise means for initiated the approach. It would then use continuous, dynamic speed guidance for active spacing relative to the leading aircraft.

Table 6. Initiating the Approach.

SATS Aircraft / Pilot	Sequence of Events	
	ATC	AMM
Determines if the preceding aircraft is sufficiently far ahead such that it can begin its own approach.		
If the preceding aircraft is sufficiently far ahead, begins the approach.		

Flying the Approach

No unique SATS HVO requirements were identified for navigation and guidance along the front-side (i.e., prior to the missed approach point) of the approach (fig. 10). The scenario sequence for this operation is shown in table 7.

During the approach, the SATS aircraft would continuously monitor, via an onboard alerting capability, the relative spacing between it and the preceding aircraft. If the following aircraft were predicted to get closer than the nominal spacing, then an alert would be given to the following aircraft to reduce its approach speed. If the following aircraft were predicted to get closer than the safety minima to the aircraft that it is following, then a procedure would be used to mitigate this situation. Also note that while the missed approach segment is part of the approach, it is discussed in a subsequent section.

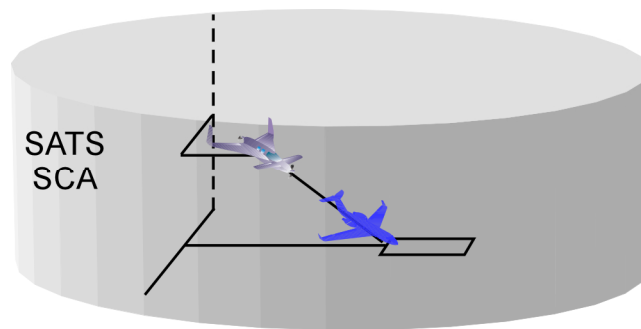


Figure 10. Flying the approach.

Table 7. Flying the Approach.

SATS Aircraft / Pilot	Sequence of Events	
	ATC	AMM
Monitoring spacing during the approach ¹ . Reduces speed if getting closer than nominal. Performs loss-of-spacing procedure if spacing is too close. Visually acquires approach end of runway (Category I conditions).		

¹ may have dynamic speed guidance.

Landing

Because the landing operation (fig. 11) would occur in visual conditions, there are no unique SATS HVO system requirements for this phase of flight. If the SATS aircraft cannot land, then the missed approach procedure would be flown.

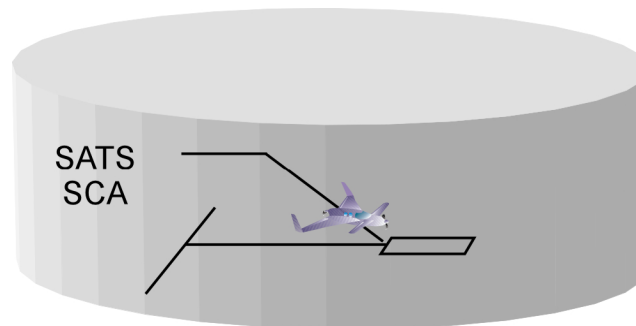


Figure 11. Landing.

Initiating a Missed Approach

Prior to issuing a FN, the AMM would determine a conflict-free, missed approach path for the SATS aircraft. A crucial element of this conflict-free path was that the AMM would not assign two consecutive aircraft to the same missed approach path, ensuring that a performance disparity between the two aircraft would not cause a conflict. The SATS missed approach fixes would nominally be the two outboard IAFs on the GPS "T" (e.g., ANNIE and CATHY, in figure 1). Aircraft on a missed approach would go to the lowest available holding altitude (fig. 12), simplifying the transition for another approach. The scenario sequence for this operation is shown in table 8.

If a missed approach was required, the SATS aircraft, as in normal IFR procedures, could begin a climb to the missed approach altitude at any point along the instrument approach path prior to the missed approach point (MAP). As in normal IFR procedures, the turn to the missed approach holding fix may not begin until the aircraft passes the missed approach point. Once the aircraft initiates its missed approach, that action is broadcast by the aircraft, and the aircraft would be automatically re-sequenced for another approach. The operation to depart the SCA from the missed approach is defined in a subsequent section.

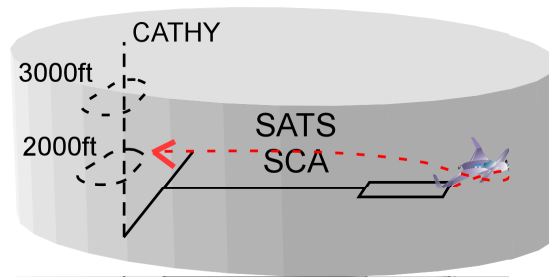


Figure 12. Missed approach.

Table 8. Initiating a Missed Approach.

Sequence of Events		
SATS Aircraft / Pilot	ATC	AMM
Initiates missed approach procedure. Aircraft broadcasts missed approach initiation.		
Determines the lowest available altitude at the missed approach fix.		
Climbs to the lowest available altitude at the missed approach fix.		
Holds at the missed approach fix.		Issues new FN and MAHF.

Initiating a Departure

A pilot who wants to depart the SATS airport would file a normal IFR flight plan that would include a designated SCA departure procedure, also noting that a traditional flight plan would also include an expected time of departure (ETD). The departure procedure would include a minimum of one departure fix outside of the SCA. In a manner similar to current operations at remote airports, approximately 30 minutes prior to the planned departure time, the pilot would contact ATC or flight service to obtain a clearance. With the receipt of the clearance, the pilot would also be informed of any expected delay that would impact the ETD. Note that the SATS pilot could only receive a short range clearance that would end at the last fix of the departure procedure.

Prior to the ETD and including any additional delay that was advised by ATC, the SATS pilot would have completed all preflight checks and be ready to depart the SATS airport. Immediately prior to the ETD, the SATS pilot would monitor the approach stream (i.e., the aircraft that are on the approach) for a potential departure slot. The determination of a departure slot could be done in a manner similar to the options used for initiating an approach (i.e., from a simple CDTI-based procedure through an advanced automation tool). Once a departure slot had been identified, the SATS pilot would contact ATC through a Remote Transmitter Receiver, Remote Communications Outlet (RCO), CPDLC, or some other means to obtain a departure release. In a normal situation, it would be expected that ATC would immediately release the SATS aircraft for entry into traditional ATC controlled airspace. This release would probably include a void time.

The SATS pilot would then confirm, or delay as appropriate to ensure, that a safe departure was possible, taxi on to the runway, and depart (fig. 13). The scenario sequence for this operation is shown in table 9.

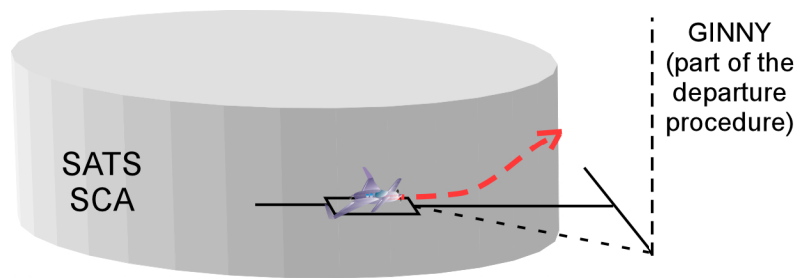


Figure 13. Initiating a departure.

If ATC were unable to accept the departure aircraft at the time of the pilot's request, ATC could provide an expected delay time. At the end of that expected delay time, the SATS pilot, having repeated the last several departure steps, would again call ATC for a departure release.

Table 9. Initiating a Departure.

Sequence of Events		
SATS Aircraft / Pilot	ATC	AMM
Files a standard IFR flight plan that includes the SCA departure procedure.		
30 minutes prior to the planned departure time, contacts ATC (direct or via Flight Service) for the clearance.		
Immediately prior to ETD, resolves a departure slot.	Provides IFR clearance and any expected departure delay time.	
Immediately prior to departure slot, calls ATC for release.		
	Provides release and void time.	
As departure slot becomes available, taxis on to runway and initiate the departure.		

Flying a Departure

The SATS pilot would depart the airport according to the departure procedure. While climbing out on the HVO departure procedure (fig. 14), the pilot would contact ATC. As the SATS aircraft transitions the SCA boundary (either laterally or vertically), ATC would assume all normal IFR responsibilities. The scenario sequence for this operation is shown in table 10.

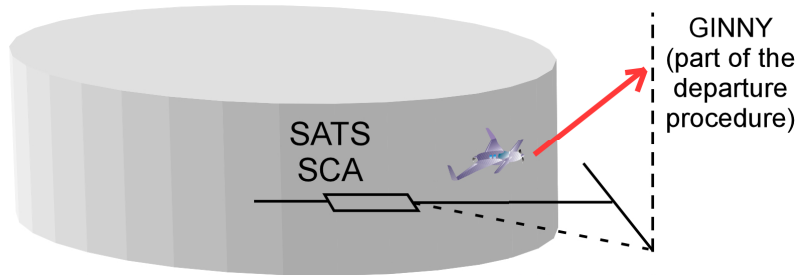


Figure 14. Departure.

Table 10. Flying a Departure.

Sequence of Events		
SATS Aircraft / Pilot	ATC	AMM
Departs the airport on a departure procedure.	ATC accepts aircraft into ATC controlled airspace.	
Establishes contact with ATC.		
Transitions into traditional ATC controlled airspace.		

Multiple Departures

If there were an aircraft that immediately preceded another departure operation, the second departing aircraft would have to perform an additional procedure to assure separation safety, beyond that defined in the previous section. If the preceding aircraft were departing on another departure route (e.g., to ELLEN), then the second aircraft would wait until the first departure reached a point on the route that assured safe lateral separation (e.g., 3 nm). If the aircraft was departing on the same route, then sufficient longitudinal separation must be assured throughout the procedure, including the transition into traditional ATC controlled airspace. Techniques similar to the determination of arrival separation for departing aircraft could be used for the determination of longitudinal separation on departure. One simple example of this technique would be to require the first departure to be 10 nm along the departure procedure (fig. 15) before the second aircraft would be allowed to request an IFR release. The scenario sequence for this operation is shown in table 11.

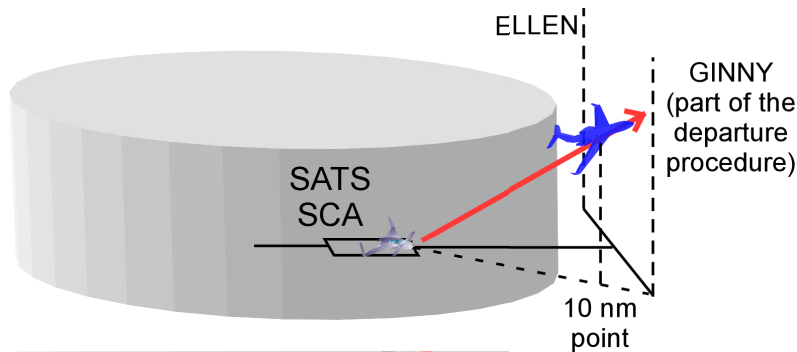


Figure 15. In-trail departure.

Table 11. Multiple Departures.

Sequence of Events		
SATS Aircraft / Pilot	ATC	AMM
<p>Perform procedures defined in <i>Initiates a Departure</i>, modified as noted below.</p> <p>Immediately prior to ETD, resolves a departure slot with arriving aircraft.</p> <p>Immediately prior to ETD, resolves a departure slot with departing aircraft.</p> <p>Immediately prior to combined departure slot, calls ATC for release.</p> <p>As departure slot becomes available, taxi on to runway and initiates the departure.</p>	<p>Provides release and void time.</p>	

Initiating a Departure from a Missed Approach

As noted in the *Initiating a Missed Approach* section, once an aircraft gets within the proximate area of the missed approach holding fix, the aircraft would be automatically re-sequenced for another approach. If the SATS pilot decided that he wished to depart the SCA and transition into traditional ATC controlled airspace, he would obtain an IFR clearance from ATC. This may be done using any of today's tools including the techniques identified in the *Initiating a Departure* section. Until a clearance and a subsequent IFR release were received, the SATS pilot would hold at the missed approach holding fix at the lowest available altitude.

It should be noted that once all of the previously sequenced aircraft land, this departing aircraft would effectively block all other arrival operations in the SCA. While several techniques have been examined to mitigate this situation, they all require further study.

Once this departing aircraft received its IFR release, the SATS pilot would fly the lateral track of the approach procedure. Unless receiving alternate transition instructions from ATC, upon turning unto the final approach course, the SATS pilot would initiate a climb to transition out of the SCA (fig. 16). The scenario sequence for this operation is shown in table 12.

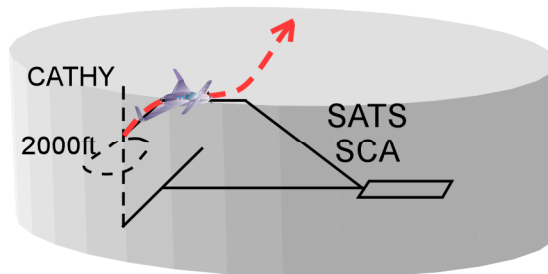


Figure 16. Departure from a missed approach.

Table 12. Departure from a missed approach.

SATS Aircraft / Pilot	Sequence of Events	
	ATC	AMM
<p>Holds at the missed approach holding fix.</p> <p>"Air files" an IFR flight plan.</p> <p>With normal approach sequencing and separation, initiates approach procedure (without descent).</p> <p>On final approach course, initiates climb to depart SCA.</p>	<p>Provides IFR clearance and IFR release to enter traditional ATC controlled airspace.</p>	

Non-equipped IFR Aircraft

An aircraft not equipped for SATS operations could use the SATS airport in a manner that would be very similar to current IFR operation. As in today's systems, the non-SATS pilot would request an instrument approach or departure from ATC. ATC would then communicate with the AMM to inhibit the AMM from accepting any new SATS HVO requests (fig. 17). The AMM would also provide ATC with the number of current operations so that ATC may estimate the expected delay time until all current SATS HVO operations were completed. The AMM would then notify ATC when the SCA becomes sterile and also that the AMM was now inhibited from further SCA operations. At this time, ATC could clear the non-SATS airplane for a normal IFR operation. Once this operation was completed, ATC would communicate with the AMM to remove the "inhibit" of the AMM so that the AMM could accept new SATS HVO requests. The scenario sequence for this operation is shown in table 13.

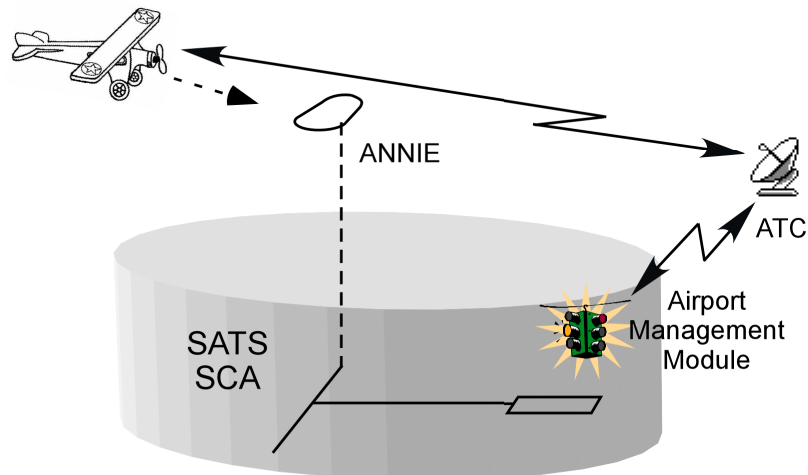


Figure 17. Non-equipped IFR aircraft.

Table 13. Non-equipped IFR aircraft.

Sequence of Events		
Non-SATS Pilot	ATC	AMM
Requests a traditional IFR departure or approach from ATC.	Acknowledges the IFR request. Sends an inhibit message to the AMM.	Sends a “sterile” and AMM inhibited message to ATC.
Completes operation, cancels IFR.	Clears pilot for IFR operation.	
	Sends a message to the AMM to terminate the “inhibit.”	

Summary

The ability to operate multiple small aircraft, in near all weather conditions, at virtually any small airport, offers a unique opportunity for revolutionary transportation growth and passenger convenience. This paper presented a concept for aircraft operating at airports where operations are currently restricted to the inefficiency of a “one-in/one-out” procedure. This new concept would allow for simultaneous operations by multiple aircraft in this non-radar “terminal” airspace around small non-towered airports. The general philosophy underlying this concept would be the establishment of a newly defined area of flight operations called a Self-Controlled Area (SCA). During periods of IMC, a block of airspace would be established around these SATS designated airports. Within the SCA, pilots, using advanced airborne systems, would have the ability and responsibility to maintain separation between themselves and other similarly equipped airplanes. Aircraft operating in this airspace would need special avionics to participate that would probably include ADS-B, a communications data link, and appropriate self-separation tools. This concept would also require a new, ground-based automation system, typically located at the airport that would provide appropriate sequencing information to the arriving aircraft.

This proposed operational concept emphasizes the integration with the current and planned near-term NAS. Additionally, the focus of the underlying design approach was on simplicity from both a procedural and a systems requirements standpoint. It was also assumed that any additional ATC workload must be minimized and that enroute procedures must be compatible with today’s ATC system. This concept is based on a distributed decision-making environment that would provide pilots the necessary procedures, tools, and information to enable safe operations within the SCA, noting that while this is a distributed decision-making environment, the majority of the decision-making responsibility would remain with the pilot.

The operational approach described in this paper was intended to be a starting point for additional designs and analyses. No attempts were made to optimize the size or shape of the proposed airspace. To date, the development focus has been on providing an operational concept that was safe, would enable more than one operation at a time, and would not require significant ground infrastructure costs or improvements. Additional research should be done to improve this initial design, both in terms of optimizing the SCA geometry and in increasing the capacity of the SCA, and batch and human-in-the-loop experiments should be performed to verify the concepts of operations. It is noteworthy, however, that this concept could be implemented and would enable more than one operation at a time. Operational

concepts, such as the one proposed here, could enhance the opportunity for point-to-point air taxi or charter operations into smaller airports, providing greater convenience to the traveling public.

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3. Conway, S.; and Consiglio, M.: *A Method Of Separation Assurance For Instrument Flight Procedures At Non-RADAR Airports*, AIAA-2002-4448, August 2002.

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14. ABSTRACT This document defines the Small Aircraft Transportation System (SATS), Higher Volume Operations (HVO) concept for normal conditions. In this concept, a block of airspace would be established around designated non-towered, non-radar airports during periods of poor weather. Within this new airspace, pilots would take responsibility for separation assurance between their aircraft and other similarly equipped aircraft. Using onboard equipment and procedures, they would then approach and land at the airport. Departures would be handled in a similar fashion. The details for this operational concept are provided in this document.						
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